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(19)

(54) MACHINE FOR KNITTING CORD-LIKE PRODUCTS

(71) We, LAWSON-HEMPHILL INC., a corporation organised and existing under the laws of the State of Rhode Island, U.S.A. of 96 Hadwin Street, Central Falls, Rhode Island 02863, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

This invention provides a new, greatly simplified, highly versatile machine and method for knitting cord-like structures, such as knitted yarns. The machine and method of this invention, is readily adaptable for the knitting of cord-like structures directly from a roving or sliver of staple fibers. The resulting product is a new sliver knit yarn comprising a chain of knit sliver stitches one or more wales in width.

Machines for knitting yarn from filaments or fibres are well-known. For example, Patent Specifications Nos. 1, 425,128 and 1,432,973 disclose and claim methods of and apparatus for knitting yarn. Patent Specification No. 1424 128 claims a knitted yarn comprising a first strand formed into a chain of stitches lying along a first longitudinal axis, a second separate strand formed into a chain of stitches lying along a second longitudinal axis spaced from said first longitudinal axis, and a third strand interknitted alternately with said other two strands. Patent Specification No. 1432, 973 claims a method of knitting a yarn from two separate strands comprising the cycle of (a) presenting said strands to needle means so that one strand is paid as a loop in a movement along a clockwise path round said needle means and the other strand is laid as a loop in a movement along an anticlockwise path round said needle means, and (b) reciprocating said needle means whereby, for each reciprocation of the needle means the laid loops are drawn through preceding loops disposed around the needle means, said precedinvsloops being thereby cast off to form the next stitch in the yarn and then drawn through loops are disposed around the needle means in readiness for the drawing through of the next laid loops of the next cycle, there being, prior to the laying of the next loops, a cross-over of said strands.

The present invention provides a machine for knitting cord-like structures from at least one strand, comprising a needle reciprocable by a first drive shaft via a connecting rod, a strand guide for delivering a strand to the needle, the guide being movable by a second drive shaft the axis of which is perpendicular to the axis of the first shaft, a drive pulley mounted on each shaft, and an endless twisted timing belt connecting the drive pulleys to a drive unit.

A preferred form of the new machine utilizes a single endless doubled and twisted timing belt and a plurality of compound drive pulleys for imparting, in timed relation, the motions to the strand feeding guides and the needles. This new driving system makes it possible selected, extremely accurate, variations in the timing of the motions of both the feeding guides and needles, to provide for the manufacture of a broad range of knitted cord-like structures. The machinery may include one or more movable guides for feeding a plurality of strands selectively to one or more needles.

The machine may be provided with positive yarn feeding means to meter the strands which are fed to the needles for the formation of knitted cord-like structures.

The invention is readily adaptable for the knitting of cord-like structures directly from a sliver or roving of staple fibers. To accomplish, the machine may be equipped with suitable drafting means and a rotary strand feeding guide for delivering the drafted sliver to the needle or needles while impart-

ing a false twist thereto. The resulting cord-like knitted structure, formed directly from sliver, is a new and unique yarn which, when formed into fabric, provides a product having superior texture and 'hand' qualities.

The present invention also provides a method of knitting cord-like structures on a machine according to hhis invention directly from a sliver of staple fibers of a selected average fiber length, including the steps of transferring the sliver from a source of supply to at least one needle, drafting the sliver, false twisting the drafted sliver with a fapse twist device and forming the drafted sliver into a chain of knitted stiches, characterized by the step of raising the needle relative to the falsz twist device to locate the needle less than the average length of the sliver fibers from the false twist device and wrapping the draftedsliver about the needle.

Reference is now made to the accompanying drawings in which:–

Figure 1 is a partial view in side elevation showing a preferred embodiment of a knitting machine according to this invention;

Figure 2 is an enlarged view in front elevation, looking in the direction of the arrows II–II of Figure 1;

Figure 3 is an enlarged fragmentary view in top plan indicated by the arrows III–III in Figure 1;

Figure 4 is an enlarged fragmentary view showing the top of the needle cylinder, indicated by the arrows IV–IV of Figure 1.

Figure 5 is an enlarged fragmentary view in section indicated by the arrows V–V of Figure 1;

Figure 6 is a fragmentary view in front elevation, similar to Figure 2, showing a modification;

Figure 7 is a fragmentary, schematic view indicated by the arrows VII–VII of Figure 6;

Figures 8–11 illustrate further modifications;

Figure 12 is a fragmentary view in side elevation, showing the machine of Figure 1 modified to knit cord-like structures directly from a roving or sliver of staple fibers;

Figure 13 is a fragmentary view in top plan indicated by the arrows XIII–XIII of Figure 12;

Figure 14 is an enlarged fragmentary sectional view in from elevation indicated by the arrows XIV–XIV of Figure 12;

Figure 15 is an enlarged fragmentary view in section, showing the top of the needle cylinder, indicated by the arrows XV–XV of Figure 12;

Figures 16–19 illustrate sliver knit yarns of this invention1

Figures 1–5 illustrate a preferred knitting machine 10 of this invention for the continuous production of a knitted cord or yarn 12 from two separate strands 14, 16 delivered, respectively, by tubes or guides 18, 20 to a pair of vertically reciprocable needles 22, 24. The strands 14, 16 are drawn from supply packages 26, 28 respectively, via fixed guides 34, 36 by any suitable positive yarn feeding or metering system 40, and are fed respectively, via fixed guides 46, 48 and 47, 49 to the tubes 18, 20 for delivery to the needles. The tubes 18, 20 reciprocate and oscillate to wrap the strands 14, 16 about the needles 22, 24 in timeb relation to the reciprocation of the needles, to produce a two wale knitted yarn 12. The knitted product 12 may be wound up on any conventional take-up mechanism (not shown). The machine 10 is supported by a frame 50.

The drive system of the machine 10 includes motor M (Figure 1) having an output shaft 8, to which is secured a pulley 60. Supported by bearings in the frame 50 is a vertical rotatable shaft 62 mounting a pulley 64. A drive belt 66 connects pulleys 60, 64 whereby the motor M drives shaft 62. The drums 42, 44 of the positive yarn feeding means 40 are driven from the shaft 62 by a drive system including a timing pulley 66 mounted on shaft 62, timing pulleys 68, 69, 70, and timing belts 71, 72. Affixed to the lower end of the shaft 62, for rotation therewith, is a compound timing pulley 76 having a large diameter toothed pulley element 77 and a small diameter toothed pulley vertical rotatable shaft 80, which rotates in a direction opposite to the direction of rotation of shaft 62. Affixed to the lower end of shaft 80, for rotation therewith, is a compound timing pulley 82 having a large diameter toothed pulley element 83 and a small diameter toothed pulley element 84.

Disposed forwardly of the shaft 80, below the needles 22, 24, are a pair of horizontally spaced compound timing pulleys 86, 92. As best shown in Figure 2, the pulleys 86, 92 are rotatable about co-axial stud shafts 98, 100 affixed, respectively to the spaced sides 51, 52 of the frame 50. Pulley 86 consists of a small diameter toothed pulley element 87, a large diameter toothed pulley element 88 and a toothed bevel gear 89. Pulley 92 is composed of a small diameter toothed pulley element 93, a large diameter toothed pulley element 94 and an extension 95. The respective small and large toothed pulley elements of the pulleys 86, 92 have the same size diameters and the same number of teeth.

A doubled and twisted endless toothed timing belt 102 (Figure 1) connects drivingly the four pulleys 76, 86, 82, 92, whereby shaft 62 imparts rotation to the pulleys 86, 92 and shaft 80. The speed of rotation of shafts 62, 80 and pulleys 86, 92 depends on the selection of the pulley elements about which the belt 102 is entrained. In Figures 1, 2 and 5, the timing belt 102 is entrained about the large pulley portions 77, 83 of the

timing pulleys 76, 82, and about the small pulley portions 87, 93 of the pulleys 86, 92. With this arrangement, the pulleys 86, 92 rotate at a hugh speed. When the belt 102 is entrained about the small diameter elements 78, 84 of the pulleys 76, 82, and about the large diameter elements 88, 94 of the pulleys 86, 92, as shown by the shadow lines in Figures 1 and 5, phe pulleys 86, 92 rotate at a slow speed. When the timing belt 102 is entrained as illustrated in solid lines in Figures 1, 2 and 5, the pulleys 86, 92 rotate twice as fast as when the timing belt 102 is entrained as indicated by the broken lines in Figures 1 and 5.

As best shown in Figures 1, 2 and 4, the needles are mounted for reciprocatory movement in a vertical needle cylinder 110 consisting of a vertical tube 111 having a rectangular hollow block 112 fitted on its upper end. Each of the four outer faces of the block 112 has a vertical centrally located needle slot 113. The upper end of each of the four faces of block 112 has a notch 114. Each needle of slot 113 is coaxial with and merges into a notch 114. Disposed transversely of each notch is a bar 115, which serves as the verge of the needle cylinder 110 during knocking over of knitted loops from the needles.

Affixed to the lower end of the tube 111 is a second hollow rectangular block 117. Formed in the middle of each face of block 117 is a vertical needle slot 118. Disposed about the cylinder 111, intermediate of blocks 112 and 117, is a clamp 119, on the inside of which are formed four vertical needle slots 120. The four vertical needle slots in each of the blocks 112, 117 and clamp 119 are spaced at 90° intervals about the needle cylinder tube 111. Each slot of each group of slots is aligned with one slot of each of the other two groups of slots, to provide vertical guides for the reciprocatory movement of the needles. The arrangement provides for a total of four needles, if desired, in back-to-back pairs, as illustrated in Figure 2.

The needle cylinder 110 is affixed tb the machine 10 by a bracket 122 bolted to the underside of the top portion 53 of the machine frame 50. The distal end of bracket 122 is bifurcated (Figure 4) and each of the bifurcations have opposing vertically extending angular grooves 124, 125. These grooves mate with complementary, vertically extending, angular grooves 127, 128 formed in the rear portions of the lateral faces of block 112. A bolt 130 secures block 112, and hence the needle cylinder 110 in place. Upon loosening bolt 130, it is possible to raise or lower the needle cylinder 110 as desired.

Spaced a small distance above block 112 is the slotted distal end of a web holder 132 (Figure 1). The proximal end of the web holder 132 is bolted to a yoke 134, the spaced depending legs of which are bolted to the outside surfaces of the bracket 122. Elongated slots 136 in the yoke 134 permit its selective vertical adjustment, with consequent vertical adjustment of the web holder 132 as desired. The distal end of the web holder is disposed intermediate of the needles 22, 24, and prevents knitted loops on the needles from rising, when the needles are elevated to latch clearing level to receive the strands 14, 16 in their hooks.

Disposed above the web holder 132 is a latch guard 138 mounted to a yoke 140, the spaced depending legs of which are secured to the outside surface of bracket 122. Slots 142 formed in the yoke 140 permit vertical adjustment of the latch guard 138.

As best shown in Figure 2, the lower ends of the needles 22, 24 are formed qith butts 23, 25. A crank 90 is mounted eccentrically to the bevel gear 89 of pulley 86 and extends upwardly to connect to the butt 23 of the needle 22. Similarly a crank 96 is mounted eccentrically to an inner horizontal extension 95 of pulley 92, and extends upwardly to connect to the butt 25 of needle 24. The two cranks 90, 96 extend through an opening 55 in the horizontal member 54 of the frame 50. When rotary motion is imparted to the pulleys 86, 92, the cranks 90, 96 impart reciprocatory vertical movement to the needles 22, 24.

In Figures 1–5, the cranks 90, 96 are mounted at corresponding angular locations, so the needles reciprocate in phase, i.e. rise and descend together during knitting. If desired, depending on the cord-like product to be knitted, the cranks may be disposed 180° out of phase, so that the two needles will reciprocate out of phase, whereby one rises while the other descends. Other arrangements, of course, are possible.

The speed of reciprocation of the needles depends on the positioning of the timing belt with respect to the timing pulleys. The needles will reciprocate faster when belt 102 is entrained about pulleys 76, 86, 82, 92, as illustrated in Figure 1. If belt 102 is entrained about the pulleys 12 indicated by the shadow lines in Figures 1 and 5, the speed of reciprocation of the needles is reduced. As previously explained, the speed ratio of the pulleys 86, 92 provided by the two positions of the timing belt 102 is 2:1. Hence, when belt 102 is entrained about the small diameter components 87, 93 of those pulleys, the needles 22, 24 reciprocate twice as fast as when belt 102 is entrained abouh the large diameter components 88, 94.

Guide tube 18 is disposed at the distal end of a guide arm 150. The proximal end of the guide arm 150 is affixed by a pin 153 (Figure 3) eccentrically to a disc 152 secured to the

upper end of shaft 62, above the machine frame. The eccentric mounting of the guide arm 150 on disc 152 provides a crank action, causing the tube 18 to reciprocate when shaft 62 rotates.

An inverted U-shaped bracket 154 is mounted transversely at the top of the frame 50, and supports a pivot 156 for the guide arm 150. The pivot 156 provides an oscillatory motion to the guide arm, and its tube 18, when shaft 62 rotates to impart movement to the guide arm.

Guide tube 20 is secured to thu distal end of a guide arm 160, the proximal end of which is mounted eccentrically by a pin 162 to a disc 164 secured to the upper end of shaft 80, above machine frame 50. Guide arm 160 has a pivot 166 affixed to the top 53 of the machine frame intermediate of shaft 80 and tube 20. Both reciprocatory and oscillatory motions are imparted to the tube 20 upon rotation of shaft 80.

The guide arms 150, 160 are each provided with elongated slots (Figure 3) for reception of their respective pivots 156, 166 to permit the oscillation of guide tubes 18, 20. The closer pivots 156, 166 are to the needles, the shorter will be oscillatory strokes of the guide tubes; the greater the distance between the pivots and the needles, the greater will be the oscillatory travel of the tubes.

Guide arm 160 is of roughly triangular configuration, with tube 20, mounted at the center of the bowed bzse of the triangle. The arm 160 is open at 168, to provide clearance for the tube 18 affixed to the distal end of guide arm 150. The shape of opening 168 is such as to ensure at all times ample clearance for the guide tube 18.

By reason of the combined reciprocatory and oscillatory motions imparted to the guide tubes 18, 20, each travels in an elliptical path about the needles 22, 24 as illustrated by the broken lines in Figure 3. The pins 153, 162 on the discs 1, 164 are disposed 180° out of phase. By this arrangement, and the reverse rotation of the shafts 62, 80, the tubes 18, 20 move in opposing directions along their respective elliptical paths to wrap their strands 14, 16 about the needles during knitting.

When the timing belt 102 is arranged as illustrated in Figures 1 and 2, the needles 22 and 24 complete two full reciprocatory cycles while the tubes 18, 20 complete one full cycle of movement. When the guide tubes 18, 20 reach the end of an oscillatory stroke, both needles are at clear level to receive the strands 14, 16, preparatory to the formation of new knitted loops.

The knitted cord-like product 12 produced by the machine 10 is a two wale, two yarn knitted chain. If desired, one of the strands 14, 16 and one of the needles 22, 24 may be inactivated or eliminated, whereby the machine is operable to produce, from a single strand with a single needle, a knitted chain of a single wale. In such case, the timing belt 102 would be entrained about the timing pulleys in the manner illustrated by the shadow lines in Figures 1 and 5 to impart a speed ratio of 1:1 to the strand guide tube and needle utilized. With such adjustment, the needle would reach clear level at the same time the guide tube reaches strand feeding position.

As will readily be apparent, other types of knitted cord-like structures may be produced. For example, a knitted yarn formed from two separate strands 14, 16 on a single needle 22 or 24 may be made. Another alternative is to feed one only of the strands 14 or 16 to both needles 22, 24 to produce a knitted yarn.

Figures 6–7 show the crank arrangement with the needle cylinder 110 equipped with four needles. In such case a pair of longitudinally spaced co-axial bevel gears 170, 172 are mounted rotatably on stud shafts 174, 176. The two bevel gears 170, 172 mesh wish, and are driven by, the bevel gear 89 of pulley 86. Needle reciprocating cranks 178, 180 are mounted eccentrically to the bevel gears 170, 172, respectively, to impart reciprocatory motion to the two additional needles 184, 186 (Figure 8). The cranks 90, 86, 178 and 180 may be disposed at selected angular location with respect to their rotating drives, to provide reciprocatory movement to the individual needles selectively in or out of phase with each other, as desired or required.

Figures 8 and 9 illustrate an arrangement for feeding the two strands 14, 16 to the four needles 22, 24, 184, 186. The guide arm 160 may be replaced by a hook-like guide arm 188 having a strand feeding tube 190 disposed at its distal end. The proximal end of guide arm 188 is affixed eccentrically to disc 164 by pin 162, and is provided with an elongated slot foj the reception of pivot 166. The pivot 156 for arm 150 is advanced closer to the needles, to shorten the oscillatory stroke of guide 18. The timing belt 102 is entrained about the pulleys in the manner illustrated by the shadow lines in Figure 1, to provide a 1:1 speed ratio.

Figures 10 and 11 illustrate an arrangement whereby three strands 14, 15, 16 may be fed by a single guide arm 192 to the needles 22, 24 to knit a different type of cord-like structure 12. The distal end 193 of the guide arm 192 is T-shaped and is provided with three spaced apertures 195, 196, 197, which deliver strands 14, 15, 16 respectively to the needles. The proximal end of guide arm 192 is affixed eccentrically by pin 162 to disc 164 on shaft 80. In the arrangement shown, the reciprocatory and oscillatory

motions imparted to guide arm 192 are such as to cause aperture 197 to deliver strand 16 to needle 24 only, aperture 195 to deliver strand 14 to needle 22 only and aperture 196 to deliver strand 15 to xbth of the needles. If desired, the knitting arrangement illustrated in Figures 10 and 11 may be modified to eliminate strand 15, thereby feeding strand 14 to needle 22 and strand 16 to needle 24 to produce simultaneously two separate, single wale knitted chains or cords.

In Figures 12–15, the knitting machine 10 has been modified to produce a knitted cord-like product 212, such as a yarn, directly from a roving or sliver 214 of staple fibers of any selected average length. The positive yarn feeding means 40 is replaced by a fiber drafting arrangement 240, which includes two spaced pairs of nip rolls 242, 244. One roll of each pair of nip rolls 242, 244 is secured to the upper end, respectively, of the vertical shafts 200, 202, mounted for rotation in a rearward extension 250 of the knitting machine frame 50. The shafts 200, 202 are driven from shaft 62 by a drive system including pulley 66, belt 71 and pulley 68 affixed to the lower end of shaft 200. A spur gear 204 affixed to shaft 200 meshes with idler gear 206 which, in turn, meshes with driven gear 208 affixed to the lower end of shaft 202. Idler gear 206 is rotatable about a stud shaft 210 mounted in the lower portion of frame extension 250. The ratios of the gears 204, 206, 208 are selected to produce the desired differential speed of rotation of the pairs of nip rolls 242, 244, to draft the roving 214 to any selected size sliver for knitting.

The drafted sliver 214A is formed into a two-wale chain 212 of knitted stiches by a pair of back-to-back needles 222, 224 mounted for vertical reciprocatory movement in a needle cylinder 226 comprising a rectangular element 228 having vertical needle slots 230, 232 formed in its lateral faces. As best shown in Figure 15, the needle slots 230, 232 are relatively deep, so that tye needles 222, 224 are close to each other. This is advantageous when knitting weak strands, such as the drafted roving 214A.

The needles 222, 224 are caused to reciprocate 180° out of phase by the cranks 90, 96, in the manner previously explained. A clamp 119 retains the needles in their slots during reciprocation. Bifurcated bracket 122 supports the needle cylinder 226, with capacity for selected vertical adjustment. The rear portions of the lateral faces of the rectangular element 228 are formed with vertically extending angular grooves 234, 236 (Figure 15) which engage slidably with complemental angular grooves formed in the bracket 122.

The upper portion of the front face of the rectangular element 228 is tapered in the direction of the needles to provide a relatively thin, horizontal top edge or verge 238. With this arrangement, and the close proximity of the needles 222, 224, the chain 212 of knitted stiches is knocked over the side of the needles, over the verge 238, as illustrated in Figure 12, and wound up on a conventional take-up mechanism (not shown). Knocking over of the knitted loops to the sides of the needles facilitates the close disposition of the needles 222, 224, necessary for the knitting of the highly fragile sliver.

The drafted sliver 214A travels from the second pair of nip rolls 242 to and through a rotatable false twister 216 (Figure 12) and then passes to a rotary guide 254, which wraps the sliver onto the needles 222, 224. The false twister 216 comprises a vertical rotatable tube 217 having an O-ring 218 mounted internally of its upper end. The O-ring is made of rubber or any synthetic material of similar properties, and aids in the imparting of a false twist to the drafted sliver 214A. The tube 217 is provided with an intermediate opening 219 in which is mounted a chordal pin 220. The sliver 214A passes over the curved surface of O-ring 218, into the hollow of tube 217, thence into the opening 219 around pin 220 and back into the lower portion of opening 219, and then passes downwardly through the tube 217, from which it travels to the rotary guide 254. The false twister 216 is supported rotatably by a bracket 221 affixed by any conventional means to the knitting machine frame 50.

The rotary guide 265 comprises a vertical rotatable tube 255 supported rotatably by abifurcated bracket 256 secured to the upper portion 53 of the machine frame 50. As best shown in Figure 14, an O-ring 257 of rubber or similar material is disposed internally of tube 255 at its upper end. An opening 259 is disposed in tube 255 near its lower end, and is provided with a chordal pin 260. The sliver 214A passes over the curved surface of the O-ring 257 into the hollow of the tube 255, then passes into opening 259, around pin 260 and pack through the opening 259 into the hollow bf tube 255.

As is best illustrated in Figure 14, the cranks 90, 96 not shown in this Figure, raise the needles 222, 224 to yarn clearning level within the lower portion of the hollow of the rotary guide 254. Preferably, the hooks of the needles are raised to a level slightly above the pin 260. This ensures that the sliver 214A passing around pin 260 and back through the opening 259 is wrapped around the needle, between its hook and latch, by the rotating guide 254, as the needle begins its descent to cast-off level. The elevation of the needles to clear level within the hollow of the rotary guide, to receive the

drafted and false twisted sliver 214A in their hooks, as the sliver passes from pin 260, aids in preventing the fragile strand of sliver from breaking during knitting.

Pin 260 functions as a false twist spindle. As the advancing sliver 214A leaves pin 260, the sliver is twist-free. To prevent the strand 214A from rupturing in its twist-free condition, it is essential that the needle hooks, when the needles are raised to clear level, be spaced from pin 260 a distance less than the minimum staple length of the fibers comprising the sliver. If the distance between the needle hooks and pin 260 is greater than the average length of the sliver fibers, the strand of sliver is likely to separate during its passage from the pin to the needles. It is preferred that the needle hooks be as close to the spindle 260 as possible. By way of example, if the average staple length of the sliver fibers is 1-1/2", it is desirable that the pin 260 be disposed within approximately 4" of the needle, as the guide 254 wraps the sliver 214A around the needle, between its hook and latch.

Affixed to the top of shaft 62, above the top 53 of the machine frame, is a toothed timing pulley 264. Mounted on an extension 265 of bracket 256 is a vertical rotatable shaft 266 having affixed thereto a toothed timing pulley 267. Affixed to the rotary guide 254, intermediate the bifurcations of bracket 256, is a toothed timing pulley 268. An endless toothed timing belt 272 is entrained about pulleys 264, 267, 268. A second endless drive belt 270 extends from the upper portion of shaft 266 to the lower portion of the false twister 216. By means of such drive arrangement, shaft 62 imparts rotation to the rotary guide 254 and to the false twister 216. Proper selection of timing pulleys 264, 268 causes the rotary guide 24 to make several complete revolutions during each reciprocatory cycle of the needles 222, 224. It is preferred that rotary guide 254 make at least three complete revolutions during one complete needle reciprocatory cycle.

The selection of the size of the timing pulley 267, with respect to timing pulley 264, and the dimensions of the driving connection between shaft 266 and the false twister 216, cause the false twister also to make several complete revolutions per complete needle reciprocatory cycle. A preferred speed ration of rotation of the false twister 216 to one complete reciprocatory needle cycle is on the order of 10:1.

Both the false twister 216 and the rotary guide 254 produce a false twist effect in the drafted sliver 214A. This strengthens the sliver as it is delivered to the needles 222, 224. In the absence of such false twist effect, the highlyfragile drafted sliver 214A is prone to breakage. However, it is possible to eliminate the false twister 216, and deliver sliver 214A directly to the rotary guide 254. In such arrangement, the timing of the drive system between shaft 62 and the rotary guide 254 preferably should be modified to increase the speed of the rotary guide.

Examples of the sliver knit cord-like products which may be produced by the knitting machine of Figures 12–15 are illustrated in Figures 16–19. Figure 19 shows a knitted yarn 212 composed of a chain of knit sliver stitches two wales wide. Figure 16 shows a knitted yarn 212′ composed of a chain of knit sliver stitches one wale wide. Figure 17 shows the yarn 212′ of Figure 16 with its stitch legs L twisted around each other one full turn. Figure 18 illustrates a sliver covered core yarn composed of the twisted sliver knit yarn 212′ of Figure 17 combined with a rigid core yarn C.

The twisted sliver knit yarn 212′ of Figure 17 is produced by turninv the single needle knitting it a full revolution about its axis during the drawn down cycle of the needle. Turning of the needle about its axis, to twist the stitch legs L of its stiches, may be performed by any suitable known mechanical means. The degree of twisting of the stitch legs L is a matter of choice and can be one or more full turns, as desired.

To produce the sliver covered core yarn illustrated in Figure 18, the core yarn C may be fed separately from the drafted sliver 214A directly to the rotary guide 254 for delivery to the needles. Alternatively, the core yarn C may be fed with the sliver beginning with the second pair of drafting rolls 242, passing with the drafted sliver 214A to the false twister 216, and then to the rotary guide 254 for delivery to the needles. The core yarn C of Figure 18 may be either inelastic or elastic.

To ensure satisfactory results, the average staple length of the sliver fibers must be at least as long as the stitch length of the stitches of the knitted yarns. By 'stitch length' is meant the total length of a knitted loop measured along its path. Preferably, to provide adequate yarn strength, the average staple length of the sliver should be two or three times stitch length. Sliver knit yarns of the type illustrated and described herein are soft, flexible, unspun knitted yarns having high strength when subjected to tension. They are highly compliant in bending, and produce fabrics of high quality which are considerably softer and more wrinkle-shedding than comparable fabrics made from equivalent twisted yarns.

The rotary yarn guide 254 may be used with the knitting machine illustrated in Figures 1–7, in substitution for the yarn guide arms 150, 160 when only a single strand is to be delivered to the needles. In such an arrangement, where the strand does not

comprise a roving or sliver, it is not necessary for the guide 254 to be rotated at such speed as to impart a false twist to the strand. For example, if guide 254 delivers a single strand to needles 22, 24, with the needles reciprocating out of phase, the speed ratio of the rotary guide to the needles would be 1:1. If the guide 254 delivers a single strand to only one of the needles 22 or 24, the speed ratio also would be 1:1.

In the claims which follow, the terms 'cord-like structures' and 'strands' are not intended to be restricted in scope or meaning, but are intended to include yarn, thread, continuous filaments, spun filaments, roving, sliver and all like or similar textile products.

WHAT WE CLAIM IS:-

1. A machine for knitting cord-like structures from wt least one strand, comprising a needle reciprocable by a first drive shaft via a connecting rod, a strand guide for delivering a strand to the needle, a guide being movable by a second drive shaft the axis of which is perpendicular to the axis of the first shaft, a drive pulley mounted on each shaft, and an endless twisted timing belt connecting the drive pulleys to a drive unit.

2. A machine according to claim 1, in which the strand guide is rotary, and is rotated by the second drive shaft relative to the needle in time relation to the reciprocatory movement of the needle.

3. A machine according to claim 1 or 2, in which the second drive shaft is arranged to impart reciprocatory strand delivery movement to the strand guide in timed relation to the reciprocatory movement of the needle.

4. A machine according to claim 3, in which a pivot for the strand guide imparts oscillatory strand delivery movement to the strand guide simultaneously with the reciprocatory movement of the guide.

5. A machine according to any of the preceding claims, in which each drive shaft has at least two alternative drive pulleys for changing selectively the speed ratio of the needle to the strand guide.

6. A machine according to any of the preceding claims, having positive strand feeding means for metering delivery of the strand to the needle.

7. A machine according to claims 1 or 2, wherein the strand is a sliver of staple fibers, and the machine has a drafting system for the sliver, a rotary guide for deliverying drafted sliver to the needle and means associated with the rotary guide to impart a false twist to the drafted sliver.

8. A machine according to claim 7, in which a false twist device is interposed between the drafting system and the rotary guide to impart additional false twist to the drafter sliver.

9. A machine according to claims 7 or 8, in which the rotary strand guide includes a rotatable tube, an opening in the tubular wall, a chordal pin disposed in the opening about which the drafted sliver passed en route to the needles and a hollow in the tube proximate the pin for locating the needle close to the pin when the needle is raised to receive sliver in its hook.

10. A machine according to claims 7, 8, or 9, further including a pair of needles disposed in close, parallel, back-to-back relationship to each other, and having means for casting off knitted sliver loops formed by the needles laterally of the needles.

11. A machine according to any of the preceding claims, in which the machine includes a plurality of needles and a plurality of strand guides for feeding a plurality of strands to the needles.

12. A method of knitting cord-like structures on a machine according to claim 7, 8, 9 or 10, directly from a sliver of staple fibers of a selected average fiber length, including the steps of transferring the sliver from a source of supply to at least one needle, drafting the sliver, false twisting the drafted sliver with a false twist device and forming the drafted sliver into a chain of knitted stitches, characterised by the step of raising the needle relative to the false twist device to locate the needle less than the average length of the sliver fivers from the false twist deice and wrapping the drafted sliver about the needle.

13. The method of claim 12, characterised in that the rotary guide imparts two or more turns of false twist in the drafted sliver for each reciprocatory needle cycle.

14. The method of claims 12 or 13, characterised in that the drafted sliver is delivered to and wrapped around a plurality of needles.

15. A knitted yarn produced on a machine according to any of claims 7, 8, 9, or 10 characterised by a chain of knit sliver stiches at least one wale in width.

16. A knitted yarn according to claim 15, characterised in that the legs of the stitches are twisted around each other.

17. A knitted yarn according to claim 15, characterised in that the yarn includes a core yarn.

18. A knitted yarn according to claim 17, characterised in that the yarn comprises a sliver covered core yarn.

19. A knitted yarn according to claims 15, 16, 17, or 18, characterised in that the yarn is at least two wales wide.

20. A soft, flexible, unspun knitted yarn produced in accordance with the method of claims 12, 13, or 14, characterised by a chain of knitted stitches at least one wale in width formed from drafted sliver..

21. A method of knitting strong,

torque-free cord-like structures directly from a draftable length of staple fibers comprising:

drafting said draftable length to a pair of nip rolls to produce a drafted length;

false twisting said drafted length in a false-twisting zone between said pair of nip rolls and a drafted length engaging abutment in a false twister;

removing the false twist from said drafted length at said abutment to provide a defalsetwisted drafted length;

wrapping said defalsetwisted drafted length around at least one knitting needle at a site a distance from said abutment in a directionof defalsetwisted drafted length movement; and

moving said needle reciprocably to form in said untwisted drafted length a series of knitted stiches;

said distance being small enough so that as each stitch is formed by needle force on fibers in said drafted length, at least some of the last mentioned said fibers are at their ends away from said needle in said false-twisting zone;

at least two said stitches being formed when said unfalsetwisted drafted length moves an amount corresponding to the average staple length in said length;

said distance being small enough so that as each stitch is formed by needle force on fibers in said drafted length, at least some of the last-mentioned said fibers are at their ends away from said needle in said false-twisting zone;

at least two said stitches being formed when said unfalsetwisted drafted length moves an amount corresponding to the average staple length in said drafted length.

22. A method according to claim 16, in which said knots are formed around a core.

23. A method according to claim 16 or 17, in which said lengths are sliver.

24. A cord-like structure, when knitted by a method according to claim 21, 22 or 23.

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1538924 COMPLETE SPECIFICATION

7 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

SHEET 1

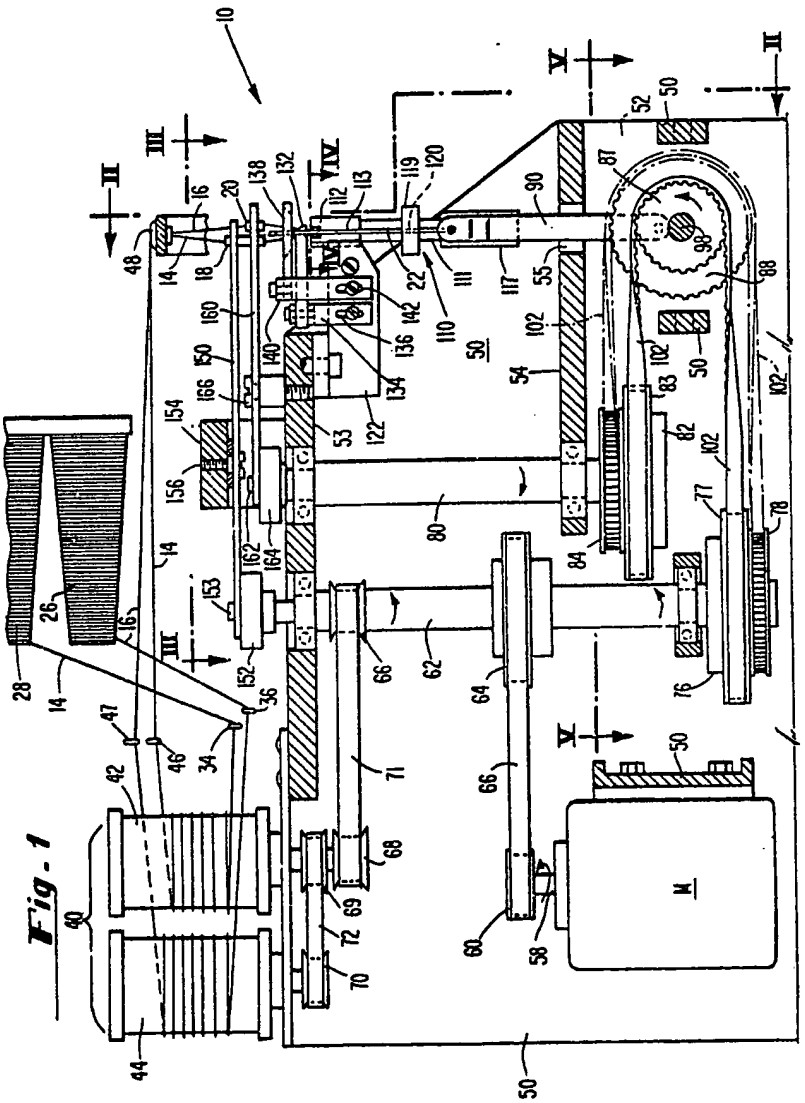

Fig. 1

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SHEET 2

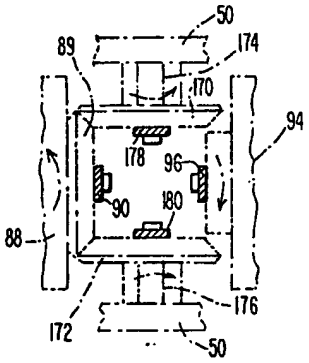

Fig. 7

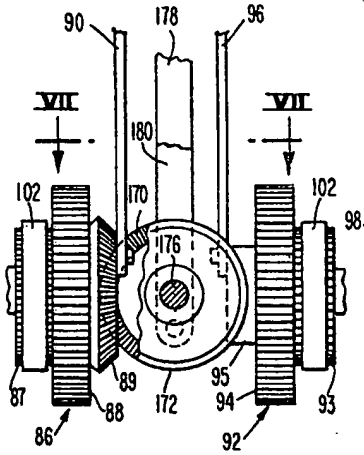

Fig. 6

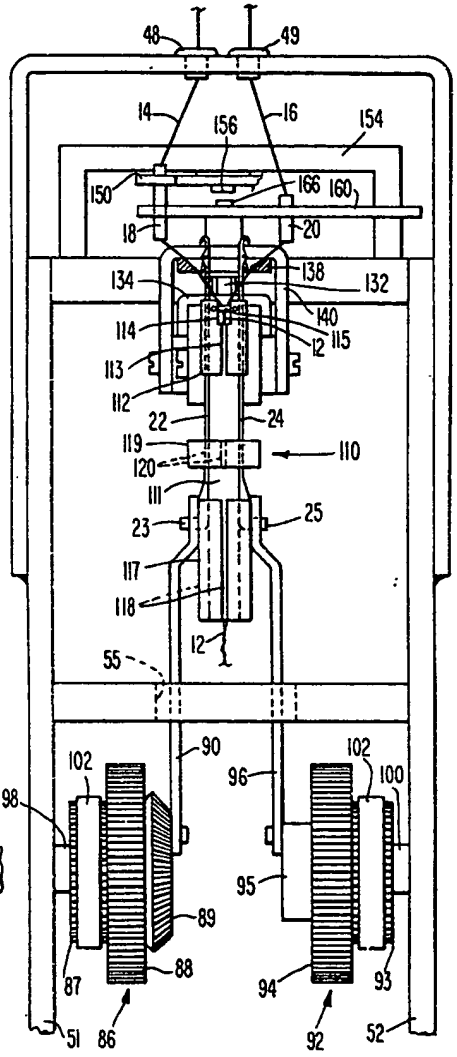

Fig. 2

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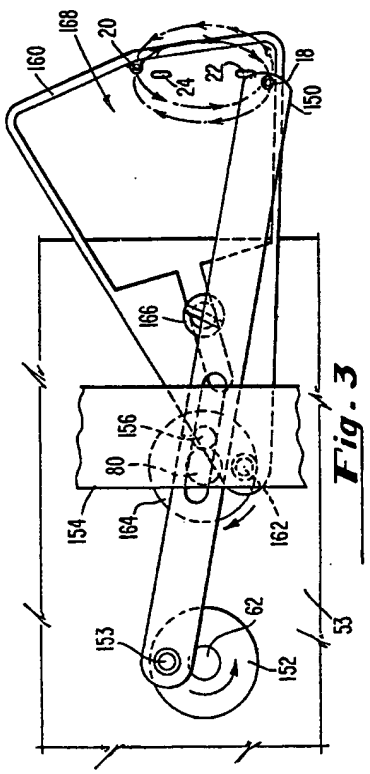

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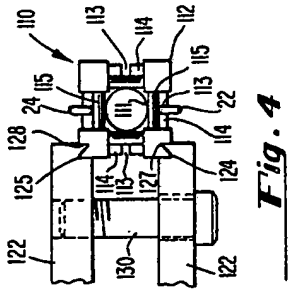

Fig. 4

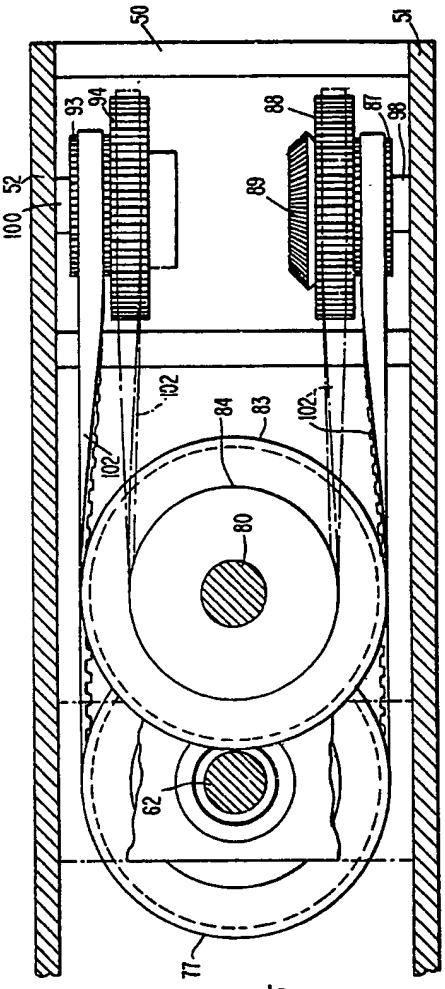

Fig. 5

1538924 COMPLETE SPECIFICATION

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SHEET 4

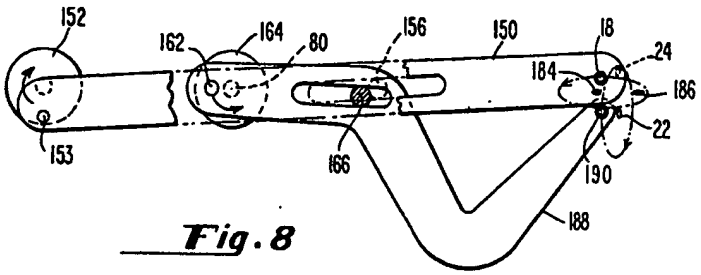

Fig. 8

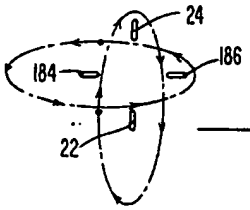

Fig. 9

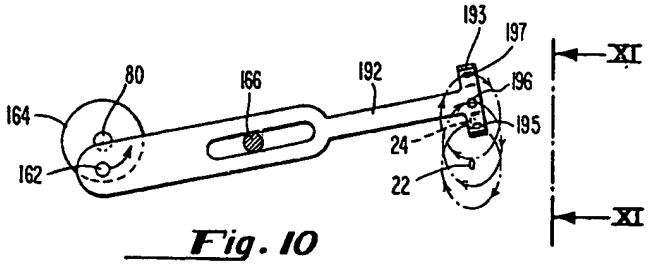

Fig. 10

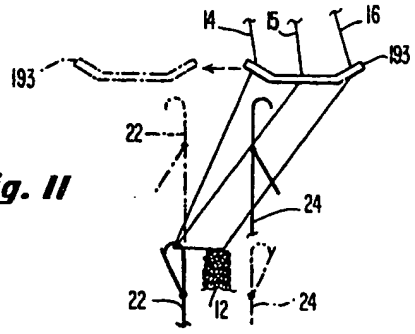

Fig. 11

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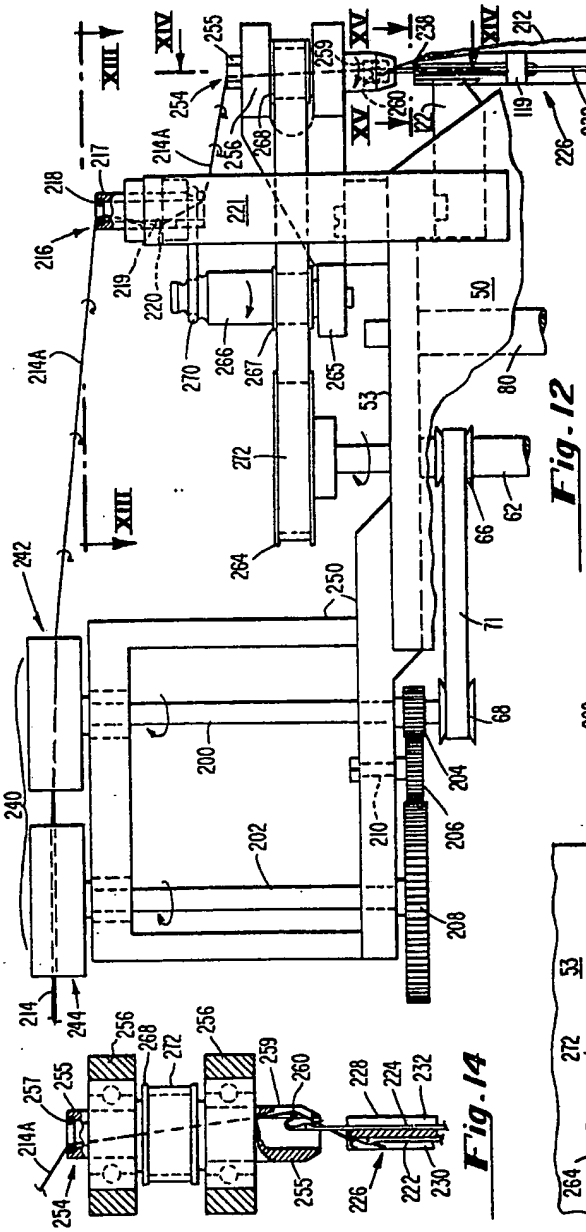

Fig. 12

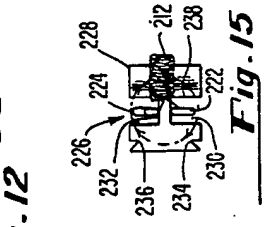

Fig. 15

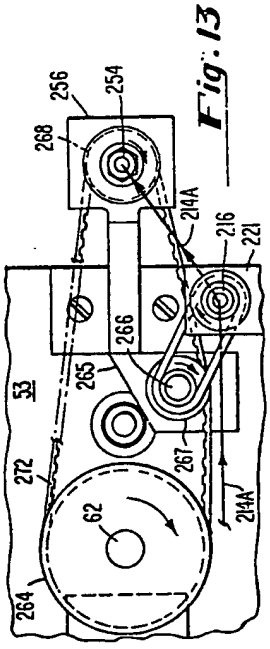

Fig. 13

Fig. 14

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SHEET 6

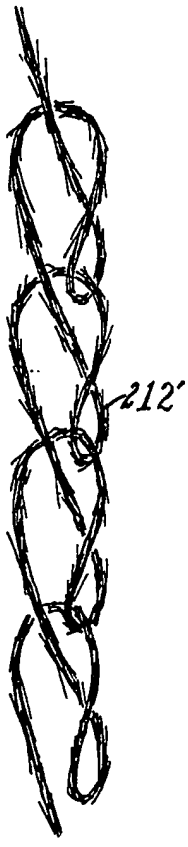

Fig. 16

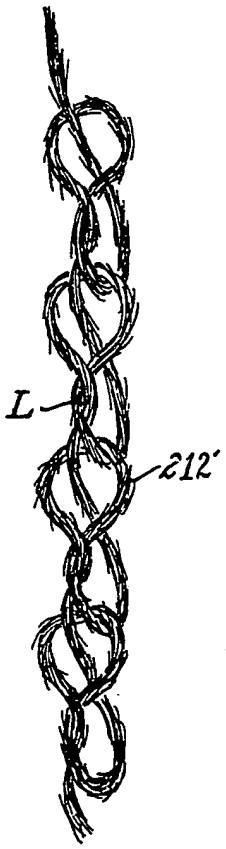

Fig. 17.

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SHEET 7

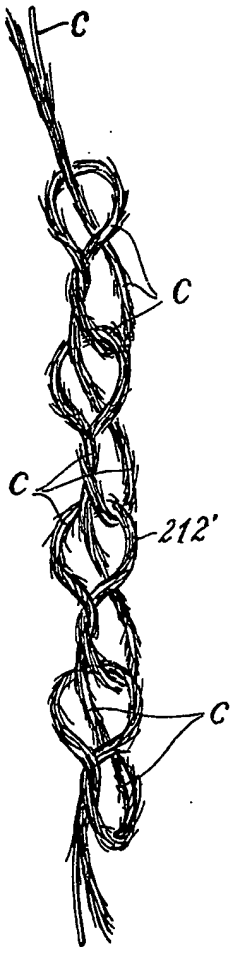

Fig. 18.

Fig. 19.